Method for control of the curl of paper in the treatment of surface-sized paper, and finishing section of a paper machine.

The invention relates to a method according to the preamble of claim 1 in the treatment of surface-sized paper, in particular fine paper in a finishing section of a paper machine. The invention also relates to a method according to the preamble of claim 4.

In addition, the invention relates to a finishing section of a paper machine according to the preamble of claim 11 for treating surface-sized paper, in particular fine paper. The invention also relates to a finishing section of a paper machine according to the preamble of claim 15.

As known in the prior art, multi-cylinder dryers of a paper machine employ twin-wire draw and/or single-wire draw. In twin-wire draw, the groups of drying cylinders comprise two wires which press the web, one from above and the other one from below, against heated cylinder surfaces. Between the rows of drying cylinders, which are usually horizontal rows, the web has free and unsupported draws which are susceptible to fluttering, which may cause web breaks, in particular as the web is still relatively moist and, therefore, has a low strength. Therefore, ever increasing use has recently been made of said single-wire draw in which each group of drying cylinders comprises only one drying wire on whose support the web runs through the entire group so that the drying wire presses the web against the heated cylinder surfaces of the drying cylinders and the web remains at the side of the outside curve of the reversing cylinders or rolls situated between the drying cylinders. Thus, in single-wire draw, the drying cylinders are arranged outside the wire loop, and the reversing cylinders or rolls are arranged inside the loop.

In the prior-art so-called normal single-wire draw groups, the heated drying cylinders are placed in the upper row and the reversing cylinders are placed in the lower row, which rows are generally horizontal and parallel to each other. When the terms "normal (drying) group" and "inverted (drying) group" are used in the following, they specifically refer to the above kind of single-wire draw groups of multi-cylinder dryers.

From the prior art it is also known to dry the paper web by means of contact-free drying. One contact-free drying method is airborne web-drying and, with respect to the prior art relating thereto, reference is made to *FI patents 98944* and *107623*. Impingement drying is also contact-free drying and, with respect to the prior art relating thereto, reference may be made, for example, to *FI patent application 20002429* and to *FI patent 106269*.

When paper is dried by means of normal single-wire draw groups from its bottom side and if this kind of asymmetric drying is extended over the entire length of the forward dryer section, the drying takes place such that the bottom surface side of the paper web dries first and with the progress of drying the drying effect also spreads to the top surface side of the paper web. The thus dried paper generally has a tendency of curling because of asymmetric drying.

As known in the art, the tendency of curling of paper is already affected in connection with the forming of the web, in particular in the sheet forming stage by the selection of a speed difference between the slice jet and the wire and by other running parameters. However, in paper machines, in particular in fine paper machines in which there is a single-wire draw in the major part of the length of the dryer section, other arrangements must also be applied in practice with a view to controlling the tendency of curling of paper in order that drying might be made sufficiently symmetric in the z-direction.

From the prior art it is thus known that paper curls if it is moistened from one side and dried from one or two sides or if paper of equal moisture is dried from one side. It is also known that the curl of paper can be controlled by means of an air dryer placed on one side, for example, by means of an impingement hood or cylinder drying from one side. When paper is dried from one side, the paper dries and curls to the dried side and the curl can also be controlled by moistening the other side of the paper by means of a moistening device and by drying it, whereby the paper is straightened.

For the purpose described above, different finishing groups for paper, in particular for fine paper have been disclosed, among other things, in the applicant's *FI patent 98387*.

With respect to the prior art, reference is also made to *FI patent 101987*, which discloses a method for drying surface-treated paper, in particular fine paper, in which method a paper web is first dried in a forward dryer section of a paper machine by means of several successive downward open single-wire draw groups on support of a drying wire, after which the paper web is finished in a finishing section, in which finishing section the web is surface-sized or coated. In the method, in the finishing section, hot moist air is supplied into connection with the drying groups to suppress evaporation or hot dry air to promote evaporation at desired sites on the desired side of the web with respect to control of curl, so that the tendency of curling of the paper web created in the paper web in the forward dryer section can be substantially eliminated and/or compensated.

With respect to the prior art, reference may also be made to *FI patent 105935*, which discloses a method for drying paper, which method comprises the following stages: a) the paper web that is being dried is passed from a press section to a forward dryer section, in which the paper web is dried from the side of its bottom surface in dryer groups that apply normal single-wire draw, which forward dryer section comprises only single-wire draw groups that apply normal

single-wire draw, b) the paper web is passed from the forward dryer section to a finishing section, in which the paper web is coated/surface-sized by a coating/surface-sizing apparatus, dried in an after-dryer section, in which the paper web is dried in at least one drying group that applies normal single wire draw, after which the paper web is calendered in a calender and passed to a reeling station, in which the paper web is wound into a machine reel. In the method, the curl of the paper web is controlled by means of at least one steam box in at least the area of the finishing section, the effect of said steam box being enhanced by cooling the web before said steam box, and in the method the curl of the paper web is controlled by elements and/or assemblies and combinations formed of said elements in at least the area of the finishing section.

Further, with respect to the prior art, reference may be made to *FI patent 101488*, which discloses a method for drying a surface-treated paper web or equivalent in an after-dryer section of a paper machine, in which method the paper web is first finished in a finishing section, in which finishing section the paper web is surface-sized or coated on both sides by means of a finishing device, after which the paper web is dried. In the after-dryer section the paper web is dried in a drying group/drying groups that apply only normal single-wire draw and in connection with or after the drying the paper web is treated by a device/devices to compensate for the tendency of curling of the paper web.

With respect to the prior art, reference may also be made to *FI patent 106270*, which discloses a method for drying a surface-treated paper web or equivalent in an after-dryer section of a paper machine, in which method the paper web is first finished in a finishing section, in which finishing section the paper web is surface-sized or coated by a finishing device, after which the paper web is dried. In the finishing section, the paper web is dried in at least one drying group that applies single-wire draw and, at the same time, the paper web is dried by an impingement apparatus disposed in connection with at least one cylinder or roll of said drying group.

One object of the invention is to develop further the arrangements described above such that the tendency of curling of paper can be controlled in an after-dryer section more effectively than before.

One problem with the arrangements known from the prior art is that the strong tendency of curling of paper dried in the forward dryer section in the downward open drying groups that apply single-wire draw and the stresses produced by it are not fully relaxed with the moistening caused by surface-sizing, in particular when changing to the use of surface-sizes with increasingly higher dry solids. One object of the invention is to provide an arrangement which makes it possible even in such a situation to eliminate or at least minimize the tendency of curling of the paper web.

One object of the invention is to propose a new arrangement for a method of finishing paper, in particular surface-sized fine paper, in which the problems associated with the curling of paper are eliminated or at least minimized.

With a view to achieving the objects described above and those coming out later, the method according to the invention is mainly characterized by what is stated in the characterizing part of claim 1.

The method according to the invention is mainly characterized by what is stated in the characterizing part of claim 8.

The finishing section of a paper machine according to the invention is in turn mainly characterized by what is stated in the characterizing part of claim 11.

In addition, the finishing section of a paper machine according to the invention is mainly characterized by what is stated in the characterizing part of claim 15.

The invention relates to a paper machine in which downward open drying groups that apply single-wire draw are used in a forward dryer section, so that a tendency of curling is created in the paper web, or in which paper machine at the end of a forward dryer section there are also drying groups that apply twin-wire draw, in which case the need for curl control is actually smaller. After the forward dryer section, the paper web is surface-sized, after which the paper web is dried in an after-dryer section of a finishing section mainly by means of contact-free drying; airborne web-drying and/or air drying and/or impingement drying and/or infrared drying. Hereafter, the term 'after-drying' is also used of the drying of the after-dryer section, i.e. advantageously at least 60 %, most appropriately at least 75 %, even as much as 90-100 % of the power needed for evaporation of the water amount between the moisture after surface-sizing and the final moisture contained in the web is produced by contact-free drying.

The invention is also suitable for use in connection with a finishing section of a paper machine which uses cylinder drying in addition to contact-free drying, however, so that at least part of the drying takes place by means of contact-free drying.

In one advantageous embodiment of the invention, at least part of the contact-free drying is accomplished by airborne web-drying in which the power of airborne web-dryers placed on the different sides of the web is adjustable in order that the stresses possibly not relaxed during surface-sizing and the curling tendency left by them may be further compensated for. The proportion of airborne web-drying in the after-drying is at least 60 %, most appropriately at least 70 %, even as much as 90 - 100 %. In connection with the invention, as contact-free drying it is also possible to use contact-free drying produced by an infrared dryer without control of curl and to dry, for example, 10 % of the after-drying by an infrared dryer. In connection with the invention it is also possible to use heating cylinders as cylinders of a holding group, in which connection they can be used for controlling curl on the bottom side of the web or only for raising drying power. In that case,

about 10 – 20 % of the water dried in after-drying can be evaporated by means of the holding group cylinders.

In another advantageous embodiment of the invention, at least part of the after-drying is also accomplished on the basis of impingement drying, in which connection impingement units provided with curl control are advantageously used. In that case, the proportion of the drying achieved by impingement is at least 50 % of the after-drying, most appropriately 70 % or even as much as 90 %. Curl can then be taken into account by dimensioning the portions of the impingement drying applied to the different sides of the web so that they are, for example, of unequal length, i.e. more top-side drying in the after-dryer section for paper pre-dried from the bottom side, so that the speeds and temperatures of the blows used in the impingement units still remain as a curl control allowance.

In accordance with a further advantageous embodiment of the invention, it is possible to use different combinations of airborne web-drying and impingement drying to build a suitable contact-free after-dryer section that controls curl.

In accordance with one advantageous embodiment of the invention, in addition to airborne web-drying, normal drying cylinder groups applying single-wire draw are used in which drying takes place as contact drying. In this kind of embodiment, the web is advantageously dried first by airborne web-drying, then by cylinder drying and after that again by airborne web-drying. By this means, the tendency to curling created in the forward dryer section can also be controlled at a high speed and when the final drying takes place as airborne web-drying from both sides of the web, so high a moisture gradient cannot be produced in the paper web as in totally one-sided drying. The drying of the web from both sides also offers more possibilities of regulation for controlling the tendency of curling.

In accordance with one advantageous embodiment of the invention, in the finishing section of a paper machine, airborne web-drying and impingement

drying are used in the after-drying as contact-free drying and, in addition to this, normal cylinder drying that applies single-wire draw. In this embodiment, impingement drying is advantageously accomplished as vertical drying, so that the after-dryer section is easily provided with enough impingement drying length. In this advantageous embodiment of the invention, airborne web-drying makes it possible to dry the web from both sides, thus allowing its susceptibility to curling to be controlled by adjusting the parameters of the airborne web-dryers and, when cylinder drying and impingement take place on different surfaces of the web, the web can be dried from both sides and, by regulating the power of impingement, it is possible to control the tendency of curling.

The method and the paper machine in accordance with the invention make it possible to control the tendency to curling created in the forward dryer section with single-wire draw.

In accordance with the invention, the after-dryer section thus uses a surface-sizing technique and contact-free drying, of which at least part is airborne web-drying or impingement drying, for control of curl. By this means, the tendency of curling of the web can be eliminated. In the invention, airborne or impingement dryers are used which are placed on both sides of the web and in which the dryers of both sides, i.e. the drying ratio between the different sides, can be adjusted separately, so that the web can be dried in a manner as required by the elimination of the tendency of curling. Advantageously, it is possible to use dryers that also make it possible to profile the drying power in the cross direction of the web, thereby also enabling the curl profile to be affected, for example, by adjusting blowing speeds and/or blowing temperature in the cross direction of the web.

The nozzle arrangement of the airborne web-dryers used in connection with an advantageous embodiment of the invention is advantageously asymmetric with respect to the top and bottom sides of the web, so that heat transfer can be made asymmetric, thus not losing drying power because of control of curl, but the

nozzle arrangement that takes into account an assumed basic curl still leaves full curl control power for use. Alternatively, in connection with the invention it is possible to operate also with a smaller curl control power, for example, with one adjustable airborne web-drying unit.

Cylinder drying is not necessarily used in the after-dryer section in accordance with the invention, but possible cylinder/roll groups must be placed in the after-dryer section to serve as web holding groups also for providing and improving the runnability of the web. However, the cylinders of said holding group can be used for increasing drying power, even though they are situated on the wrong side of the web from the viewpoint of curl. The cylinders that dry the bottom surface of the web can, however, be also used in the control of curl as a control allowance for the opposite side.

In those embodiments of the invention in which cylinder drying is used in the after-dryer section of the finishing section, by regulating the power of drying cylinders it is possible to regulate the intensity of the drying that takes place by means of contact drying as compared to contact-free drying in after-drying, so that curl can also be controlled by means of cylinder drying parameters.

In one advantageous embodiment of the invention, the drying after surface-sizing in the after-dryer section has been arranged mainly by means of airborne web-dryers - the drying accomplished by the airborne web-dryers being at least 60 %, most appropriately 70 % - which airborne web-dryers are placed on both sides of the web, so that the asymmetric drying produced in the forward dryer section can be corrected, when the airborne web-dryers placed on both sides of the web have separate control of drying power, advantageously control of blowing speed and/or temperature.

In accordance with another advantageous exemplifying embodiment of the invention, surface-sized paper is dried by air dryers which are placed on both

sides of the web and in which the temperatures and blowing speeds of the different sides are advantageously regulated separately. In this advantageous embodiment of the invention, curl is controlled by a two-sided dryer whose different sides can be adjusted independently of each other, thereby avoiding the use of moistening water and the considerable drying costs caused by it.

In accordance with one advantageous exemplifying embodiment of the invention, the control of curl in the after-dryer section is assisted, when needed, with a steam box, which steam box can be used, for example, such that if the paper is naturally straight, the steam box is not used because there is no need for control of curl. If the paper web curls with its edges upwards, as is the most common tendency after a forward dryer section with single-wire draw, the steam box is used, and if the paper web tends to curl with its edges downwards, for example, the cylinders of a holding group of the after-dryer section are used. The steam box is advantageously placed in a position immediately before a reel-up, where the web is colder than in the dryer section, and it is not needed much because drying has mainly taken place by means of contact-free drying.

In accordance with one advantageous embodiment of the invention, impingement drying is used for contact-free drying and with respect to the prior art relating thereto reference may be made to the applicant's *FI patent application 20002429* disclosing arrangements for paper with no surface size and to the applicant's *FI patent 106269* disclosing impingement arrangements which are applied to the forward/after-dryer section and whose applications can be made use of in connection with the invention.

In accordance with one additional feature of the invention, as a possibility of control is used impingement drying in which an impingement drying unit is arranged, for example, in connection with a reversing cylinder or a grooved guide roll or a suction roll or a suction cylinder, advantageously a suction cylinder of the type marketed by the applicant under the trademark VAC ROLL. The

impingement drying units used in connection with the invention may also be so-called vertical impingement units, the details of which are described in greater detail, for example, in the applicant's above-mentioned FI patent application 20002429.

When needed, possible curl in a paper that has been lightly coated with a size-press or by other means can also be corrected in the manner described above. However, the control of curl in coating is usually not necessary, but when changing to thin coatings with higher dry solids, it may become necessary to do so with possibly further slight calendering (which also has a curl controlling effect). In coated paper it is then possible to control the movements of water in the paper with a view to also reducing the smoothness two-sidedness caused by fibre roughening in the paper and the dusting caused by binder migration.

In the following, the invention will be described in greater detail with reference to the figures of the appended drawing, but the invention is by no means meant to be narrowly limited to the details of them.

Figure 1 is a schematic view of one embodiment of the invention.

Figure 2 is a schematic view of another embodiment of the invention.

Figure 3 is a schematic view of a further embodiment of the invention.

Figure 4 is a schematic view of a further embodiment of the invention.

Figure 5 is a schematic view of a further embodiment of the invention.

Figure 6 is a schematic view of a further embodiment of the invention.

Figure 7 is a schematic view of a further embodiment of the invention.

Figure 8 is a schematic view of a further embodiment of the invention.

In Figs. 1-8, the same reference numerals are used of parts that correspond to one another, unless stated otherwise.

Fig. 1 is a schematic view of one embodiment of the invention in which a paper web W is passed from a forward dryer section (not shown) to a surface-sizing station 20, in which the paper web W is surface-sized on both sides in a nip between rolls 22, 23, in which nip the web W becomes moist on both sides because of an aqueous surface-sizing agent. In that connection, the web asymmetrically dried in the forward dryer section and tending to curl is treated so that it will be in a state in which its internal stresses relax or at least diminish. The surface-sizing agent is passed onto the surface-sizing rolls 22, 23 from a feed device 21, 24. After that the web W is passed to contact-free drying and the web W is first dried by airborne web-drying devices 31, 32 placed on both sides of the web. After that the web is passed over a cylinder or roll 33 and its top surface is dried by impingement drying by means of a drying air flow fed from an impingement hood 34. After that there are airborne web-drying units 35, 36, by which the web is dried further from both sides. After that the web is passed to a holding group formed of two cylinders/rolls 41, 42 and comprising a wire 46 which supports the run of the web while it runs on the cylinder 42. A steam box 45 is arranged in connection with the holding group for further control of the tendency of curling, when needed. Frame structures and foundations are denoted with the reference numeral 10.

In the exemplifying embodiment shown in Fig. 2, the initial part of the embodiment corresponds to Fig. 1. After the holding group 40, the web is passed over a cylinder 43 further to another contact-free drying step, in which there are first airborne web-drying units 51, 52 that dry the web from both sides. After this there is a cylinder or roll 53 over which the web is passed and, at the same time, it

is dried from the side of the top surface by impingement drying by means of impingement drying air blows produced from an impingement hood 54. After that the web is passed further between airborne web-drying units 55, 56, where the web is dried from its both sides and after which there is a second holding group 60, which comprises cylinders/rolls 61, 62 and a wire 66 supporting the web on the cylinder 62, as well as a steam box 65 arranged in connection with the holding group, which steam box makes it possible to further control the tendency of curling of the web, when needed.

In the embodiments shown in Figs. 1 and 2, the airborne web-drying units 31, 32, 35, 36, 55, 56 can be controlled such that the drying power of the web can be regulated on its different sides, whereby the tendency of curling of the web possibly remaining in the web after surface-sizing can be corrected. When desired, the airborne web-drying units can be provided with a possibility of profiling, in which case the drying power produced by means of them can be regulated, for example, through blowing speed and/or temperature in the cross direction of the web, thus also making it possible to adjust the curl profile of the web.

The impingement hood 34 can also be accomplished, when needed, such that its power can be profiled in the cross direction. The roll or cylinder 33, 53 arranged in connection with the impingement hood can be in structure of the drying cylinder type, a paper guide roll or a suction roll, for example, a suction roll, without an internal suction box, of the type marketed by the applicant under the trademark VAC ROLL.

Fig. 3 is a schematic view of one paper machine in which one embodiment of the invention is used. Stock is fed from a headbox H of the paper machine to a web forming section F, in which a web W is formed and water is removed from it. In a press section P, water is removed further from the web in press nips, whereafter the web W is passed to a forward dryer section D. The forward dryer section D

comprises several downward open drying groups G_1, G_2.. G_6 that apply single-wire draw. After the forward dryer section D, the web W runs through a measuring unit M to a surface-sizing unit 20, after which the web W is dried from both sides by airborne web-dryers 31, 32 placed on both sides of the web, the power of each of which airborne web-dryers 31, 32 can be regulated separately to control the tendency to curling. The web is passed over a roll/cylinder 33 to the next airborne web-drying stage, in which the web is further dried from both sides by an airborne web-dryer 35, 36 placed on both sides of the web, which airborne web-dryers can be controlled separately such that the tendency to curling can be controlled by means of drying power. When desired, the airborne web-drying units 31, 32, 35, 36 can also be controlled in the cross direction of the web W, whereby it is also possible to affect the curl profile. After that there is a holding group 40 formed of cylinders/rolls and serving as a holding group, which holding group 40 comprises a cylinder/roll 41, 42, 43, 44 and a wire 46 as well as a steam box 45 placed in connection with the cylinder/roll 43 of the lower row. After that the web is calendered in a calender C, whereafter the web W is passed to a reel-up R to wind the web into machine reels.

Fig. 4 is a schematic view of an embodiment of the invention which uses so-called vertical impingement units 72, 73, 74 and, with respect to their further details, reference may be made, for example, to the applicant's FI patent application 20002429. Each vertical impingement unit 72, 73, 74 comprises impingement hoods 91, 92 which are placed substantially perpendicularly to a substantially horizontal machine direction and in which a web W runs on support of wires 95 in the impingement units 72, 74 placed above the web W above the machine plane and, in the impingement units 73 placed below, the web W runs on support of a wire 79 of a holding group. The wire draw is supported by means of alignment and guide rolls 94 and reversing cylinders or rolls 93. In the embodiment shown in Fig. 4, a surface-sizing unit 20 is followed by an airborne web-dryer or infrared dryer 70 that dries the web W from both sides and after which the impingement drying units 72, 73, 74 are arranged in connection with holding groups that apply

single-wire draw. From the airborne web-dryer or infrared dryer 70 the web W is passed over a reversing suction roll 71 to the first impingement drying unit, which is followed by the holding group 79 which applies single-wire draw and whose wire is denoted with the reference numeral 79 and in connection with which one impingement drying unit 73 is placed. The cylinders of the holding group are designated by the reference numerals 75, 76, 77 and 78. The latter upper impingement unit 74 is followed by a holding group, whose wire is designated by the reference numeral 83 and whose cylinders/rolls are designated by the reference numerals 81, 82. From the reversing suction roll 71 the web W is passed to the first impingement drying unit 72, in which the web is dried on the top surface and its curl is controlled by means of drying blows produced by the impingement hoods 91, 92. After that the web W is passed to the so-called lower impingement drying unit 73, which dries the other side of the web W and which can also be curl-controllable in its structure, whereafter there is a holding group that applies single-wire draw and in which the cylinders are designated by the reference numerals 75, 77 and the wire by the reference numeral 79 and the reversing suction rolls by the reference numerals 76, 78. After that there is further one so-called vertical impingement drying unit 74, whose structure corresponds, for example, to that of the first upper impingement drying unit 72 and which can also be curl-controllable in respect of its structure and adjustable in respect of its blowing speeds and power. After that there is further a group which is formed by a cylinder 81 and a wire 83 as well as a reversing suction roll 82 and serves as a holding group. In Fig. 4, suction boxes 99 placed at locations of transfer of the web are used for guiding the web W and for assuring the transfer. In the holding groups, the cylinders are in the upper row, except at the impingement units, and the reversing suction rolls are in the lower row.

In the schematic embodiment shown in Fig. 5, both airborne web-drying and impingement drying are used for control of the curl of the web W. The web W is passed from a surface-sizing unit 20 to airborne web-drying accomplished by means of airborne web-drying units 31, 32 placed on both sides of the web W, the

power of which airborne web-drying units can be advantageously regulated and which airborne web-drying units can also be advantageously controlled in the cross direction of the web W to control the curl profile. The airborne web-drying is followed by a so-called vertical impingement drying unit 72, in which the web W is dried on its top surface. Hoods of the impingement unit are denoted with the reference numerals 91, 92 and during impingement drying the web W runs on support of a wire 95. After that the web W is passed to the next impingement drying unit 73, in which the web W is dried from its other side and the structure of which corresponds, for example, to that described above. Of course, the dimensions of the hoods and the heights of the units are dimensioned as needed. The impingement units can be controlled in respect of their blowing speed and power. After that the web W is passed to airborne web-drying, which is accomplished by means of airborne web-dryers 35, 36 placed on both sides of the web W. After that there is a holding group whose wire is designated by the reference numeral 87 and upper-row cylinders by the reference numerals 84, 86 and lower reversing suction roll by the reference numeral 85.

In the exemplifying embodiment of the invention shown in Fig. 6, the web W is passed from a size press 20 to an airborne web-drying portion, which is formed by airborne web-drying units 31, 32 placed on both sides of the web W. After that, in the after-drying there is a cylinder drying portion 100 that applies cylinder drying and which in the embodiment of the invention shown in Fig. 6 comprises two drying groups 101 and 102 that apply normal single-wire draw, the drying wire of said drying groups being denoted with the reference numeral 105 and the drying cylinders of them with the reference numeral 104 and the reversing rolls/reversing cylinders of them with the reference numeral 103. After this cylinder drying portion 100 there follows airborne web-drying in two airborne web-drying units, in both of which the web is dried by means of airborne web-drying units 35, 36, 37, 38 placed on both sides of the web W, and finally there follows a cylinder group which serves as a drive group and comprises a drying wire 87, drying cylinders 86 and 84 and a reversing cylinder 85. After a calender C the web is

passed to a reel-up R. In this embodiment of the invention, the tendency of curling of the web created in a forward dryer section is controlled primarily by adjusting the drying parameters of the airborne web-drying units. More drying can be arranged particularly for the top surface of the web by adjusting the heat and/or the blowing speed of the airborne web-drying unit on the top side to be higher than that/those of the airborne web-drying unit underneath the web. In addition, the control of the tendency to curling can be affected by adjusting the drying parameters of drying cylinders 10, for example, the regulation of steam pressure is used for affecting the surface temperature of the cylinders and, thereby, the proportion of the drying applied to the bottom side of paper.

In the exemplifying embodiment of the invention shown in Fig. 7, the web is passed from a size press (not shown) to an airborne web-drying portion, which is formed by airborne web-dryers 31, 32 placed on both sides of the web W, after which there follows, as in the embodiment shown in Fig. 6, a cylinder drying portion 100 comprising two drying groups 101, 102 that apply normal single-wire draw. Whereafter the web is passed to a vertical impingement drying group 110 by means of cylinders 107 and 108. Impingement drying hoods are denoted with the reference numerals 91, 92 and 96, of which the hood 96 is placed in connection with a reversing cylinder 93 and the impingement hoods 91, 92 on the substantially vertical runs of the web. The guide rolls of the impingement group are denoted with the reference numeral 94 and the runnability components supporting the running of the web are denoted with the reference numeral 105. After the impingement drying the web is passed to a drive group, which is formed by cylinders 82 and 84 and from which the web is passed over a reversing cylinder 82 to a calender C.

The exemplifying embodiment of the invention shown in Fig. 8 corresponds in its essential parts to that shown in Fig. 7, with the difference that the reversing cylinder VAC ROLL placed in the position 88 has been replaced with a cylinder/a smooth or grooved guide roll.

In the figures described above, the blowing speeds and powers of the airborne web-dryers and impingement drying units can be regulated, when needed, to accomplish the control of curl and, in addition, they may also enable the control of curl to be profiled in the cross direction of the web W.

In connection with the figure, it shall be particularly taken into account that the dimensions of the impingement hoods and the heights of the units are meant as a general guide and their dimensioning is accomplished as needed.

The invention has been described above only with reference to some of its advantageous exemplifying embodiments, but the invention is not by any means meant to be narrowly limited to the details of them.